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EVALUATION OF SEVERAL FORECASTING TECHNIQUES FOR RETAIL LEVEL S--ETC(U)

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EVALUATION OF SEVERAL FORCASTING TECHNIQUES FOR RETAIL LEVEL STOCKAGE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Various models for forecasting demand rates for retail level stockage are evaluated. A 12-month moving average using individual unit history outperformed those models evaluated.

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SUMMARY

Background

Army retail units now maintain a Prescribed Load List (PLL) of parts experiencing at least three demand per six months to add and one demand per six month period to retain the item as stocked. If stocked, the average monthly demand is computed using a six month moving average base. This AMD is used to compute the retail stockage levels.

Objective and Purpose

Much of the work in forecasting suggests that longer base periods result in more accurate demand forecasts. To determine if this holds true for forecasting the highly erratic demand at retail units, this work compared various base periods using cost and demand satisfaction to evaluate the performance.

The second part of the work concentrated on evaluating a method to compute the AMD by consolidating demands from all retail units within a division structure for a particular NSN. The rationale was similar to that for expanding the length of the base, — the more demand experience available, the more accurate should be the forecast. This model, however, is only applicable if the equipment densities are the same at each unit as is the case at the 82nd ABN Division. If this is not the case, an adjustment to the forecasted quantities to be stocked must be made to compensate for end item density at different units.

Scope

This work is limited to forecasting PLL demands for secondary items, excluding QSS (Quick Supply Store) and reparable items.

Findings and Conclusions

Twelve month base periods outperformed the six month base currently used in forecasting PLL demand. The difference between consolidating like unit demands and using individual unit histories was minimal. Based on implementation considerations and the difficulty of adjusting for end item density, we feel forecast should continue to be made using individual unit demand histories but with a twelve month base. Verifying these results using statistical significance tests were inclusive. Further verification of the models/bases will be made at a future date using the RIMSTOP simulator.

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CHAPTER I

EVALUATION PROCEDURE

1.1 Data Base

Individual unit demand histories were used for the nine maneuver battalions at the 82nd ABN Divisions. These data represented demand submitted from December 1977 through November 1979. Items with demand frequency less than three in the base period are excluded because these are typically non-stocked items.

1.2 Models

a. Individual/Moving Average: $F_i = \sum_{j=1}^{L} d_j / L$

where

F_i = forecast for the i^{th} item

d_j = demand in the base period L

L = length of base period: L = 6, 12, 18

b. Rolled ÷ $F_i = \sum_{k=1}^{n} \sum_{j=1}^{L} d_{jk} / Ln$

where

n = number of units having non-zero demands for the i^{th} item

1.3 Performance Statistics

Evaluation was made by comparing the demand satisfaction and cost of stockage for the various models and bases. The best model is the one which will provide a given performance level for the least cost. The most accurate means of obtaining these performance statistics is by simulation. However, such simulation is very costly and time consuming.

An alternative method was developed whereby each forecast (F_i') for the bases and models was adjusted by a percentage of the forecasted demand after which the demand satisfaction was computed. The adjustment is:

$$F_i = F_i' + u_k F_i'$$

where $u_k = [-.9, -.8 \ldots\ldots 0, \ldots\ldots\ldots 8, .9]$

Demand satisfaction is computed using:

$$\sum_{i=1}^{n} \min (F_i, A_i) / \sum_{i=1}^{n} A_i$$

where A_i = actual demand for the i^{th} item

F_i = forecasted demand for the i^{th} item using a base period n.

Therefore, for each policy tested, we were able to use the 10 data points to draw a curve of demand satisfaction versus dollar value of forecast. By plotting these curves for all models/bases on the same graph, we are able to pick the model with the desired performance at the least cost. This procedure of using cost/performance curves as an evaluation tool is fully described in Inventory Research Office report.*

This methodology of evaluating the models assumes the inventory policy in effect is one in which overall investment cost is adjusted by a lambda control knob. Therefore, these results are applicable only when RIMSTOP is fully implemented at the retail level.

*"Evaluation of Several VSL/EOQ Models," May 1974, Deemer & Kruse.

CHAPTER II

RESULTS

The first comparison is made between individual forecast using 6-month and 12-month bases. As seen in Figure 1, the 12-month base outperforms the 6-month. At a cost of $53500 of forecasted dollars, the 6-month base had a demand satisfaction of .41, the 12-month .445 or a 9.2% difference. One should not equate these demand satisfaction figures with actual field experience since a full RO is not included and no on-hand stock is considered.

Next we compare the rolled with the individual model. For a 6-month base (Figure 2), the rolled clearly outperforms individual; for the 12-month base (Figure 3), there is little difference.

These results are consistent with the findings on base period where more data is better. By rolling the demands when using a 6-month base, more history is available to make an accurate forecast. The differences between rolled and individual forecast diminish as the base period increases.

The last chart (Figure 4) shows all the curves together. From best to worst the rankings are: 12-month rolled, 12-month individual, 6-month rolled, 6-month individual. The difference between the top 2 is slight, however, and recommendation of the best model must consider the implementation at the retail level.

As the current system is designed at the retail level, increasing the length of the data base would be relatively simple. However, to collect demand from each unit, compute a forecast and distribute the demand over the units would require additional programming of existing ADP systems. Also, if differences exist in density of equipment at each unit, this factor would have to be applied in the distribution of stock.

Since the gain in demand satisfaction/cost is so small between 12-month individual and 12-month rolled, we feel the 12-month individual forecast is best when implementation problems as well as cost/performance relationships are considered.

CHAPTER III

SIGNIFICANCE TESTING FOR DIFFERENCE IN COST CURVE

The conclusions presented so far were based on a visual inspection of the cost/performance curves and a calculation of the percent improvement. However, a more rigorous evaluation of the difference in performance was desired.

Significance testing is desirable because the observed differences in the cost/performance can be caused by the large variability of item demand satisfaction for each model/base. The statistical approach chosen was the T-test for difference in means between two populations.

The first problem surfaced when computing the variance of item demand satisfaction. The equation for demand satisfaction:

$$\text{Dem Sat} = \sum_{i=1}^{n} \frac{\min(F_i, A_i)}{\sum_{i=1}^{n} A_i}$$

Can be written:

$$\text{Dem satisfaction} = \frac{\min(F_i, A_i)}{A_i} * \frac{A_i}{\Sigma A_i}$$

When the variance is computed, we see the result is the variance of the demand forecast or the actual demand. Since demand fluctuates wildly, the variance is extremely high, and would always result in a T-test conclusion that the model/base differences were insignificant.

An alternative approach is to compute the variance base or the difference between item demand satisfaction. However, this presents another problem: Should the individual observations be weighted according to the quantity of demand? First we will discuss the weighted approach in reference to comparing the rolled and individual model.

Let

S_{iF} = demand satisfaction

i = item $\quad i = 1, n$

F = forecast method $\quad$ 1 = rolled

2 = individual

The weight applied to each S_{iF} is

$$w_i = \frac{A_i}{\sum_{i=1}^{n} A_i}$$

where A_i is the demand for the item in the forecast target month.

Define $d_i = (S_{i2} - S_{i1})$, the difference between the two models' resulting demand satisfaction for the i^{th} item.

Therefore $\bar{d}_w = \sum_{i=1}^{n} (S_{i2} - S_{i1})$ wi

The variance of $\bar{d}_w$ = is

$$\text{Var } \bar{d}_w = \sum_{i=1}^{n} w_i^2 \text{ var } \bar{d}$$

where $$\text{Var } \bar{d} = \frac{\sum_{i=1}^{n} d_i^2}{N} - \bar{d}^2$$

Using the T-test to determine if the differences are significant the hypotheses are:

$$H_0: \ \bar{d}_w = 0$$

$$H_1: \ \bar{d}_w \neq 0$$

with the T statistic equal to

$$T = \bar{d}_w / \sqrt{\text{var } \bar{d}_w}$$

Using this approach to test the differences between the 6-month base individual vs rolled results (Figure 1) we find

$$\bar{d}_w = -.02959$$

$$\text{Var } \bar{d}_w = .00117747$$

$$\text{and} \quad T = .86$$

This T value gives only a 60% confidence in rejecting the H_0 in favor of concluding that the difference in the means is due to the forecast model.

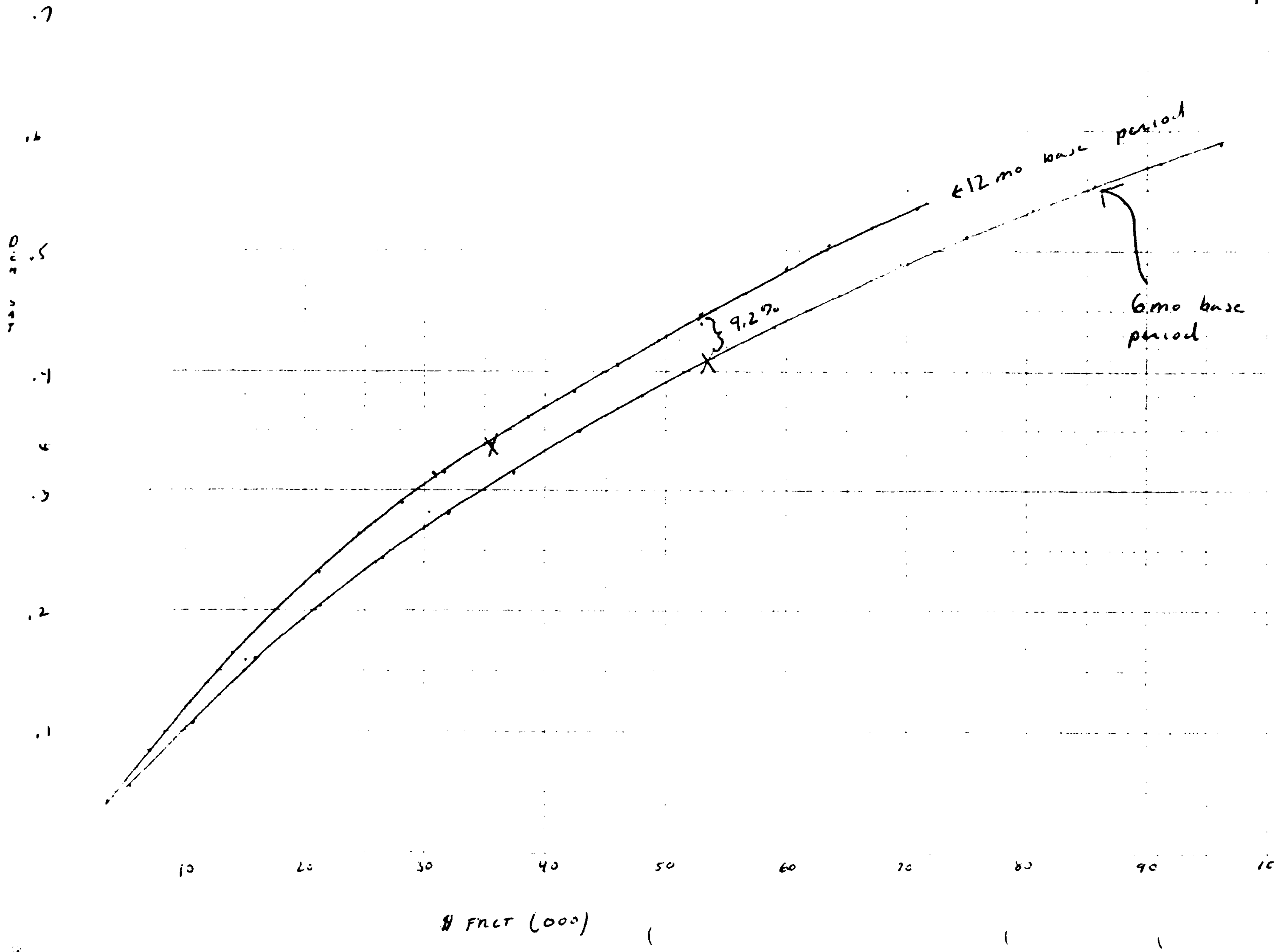
The second approach would be to compute the differences in demand satisfaction unweighted. Using the same approach as described before, except droping the w_i term we arrive at a T of 3.22 or a 99% confidence for rejecting the null hypothesis in favor of concluding there is a significance in the forecast models.

This work was performed comparing other pairs of models/bases with the results the same. The weighted version of the T-test did not prove significant enough to conclude a true difference existed; the unweighted version consistently found significant differences in the models/base comparisons. We have no rationale for explaining these outcomes.

Since the statistical significance results are not conclusive, we intend to do further evaluation of the models/bases by means of simulation at a future date.

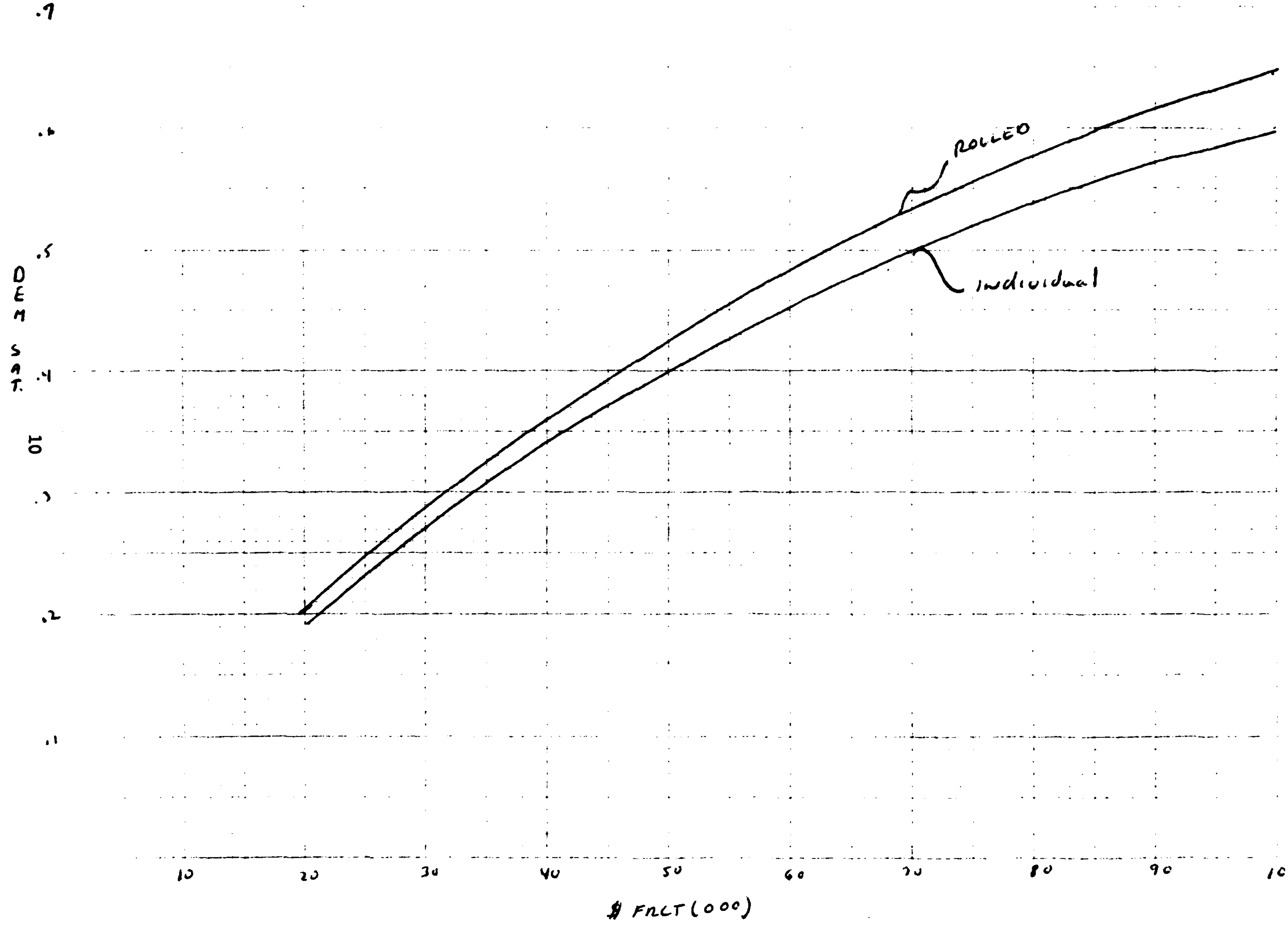
Individual Forecasts - 6 months vs 12 months

Figure 1



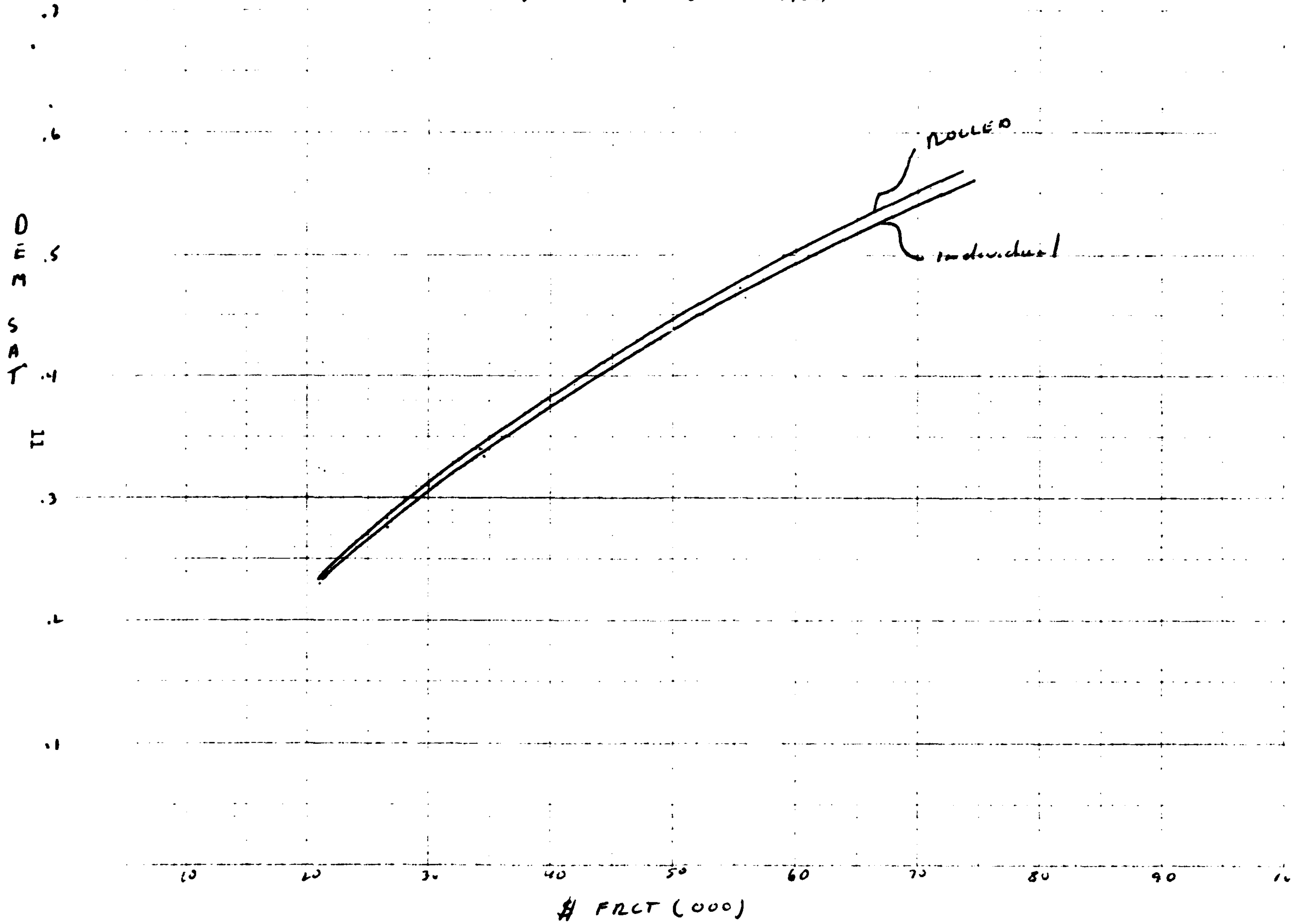
6 month base - individual vs rolled forecast

Figure 2



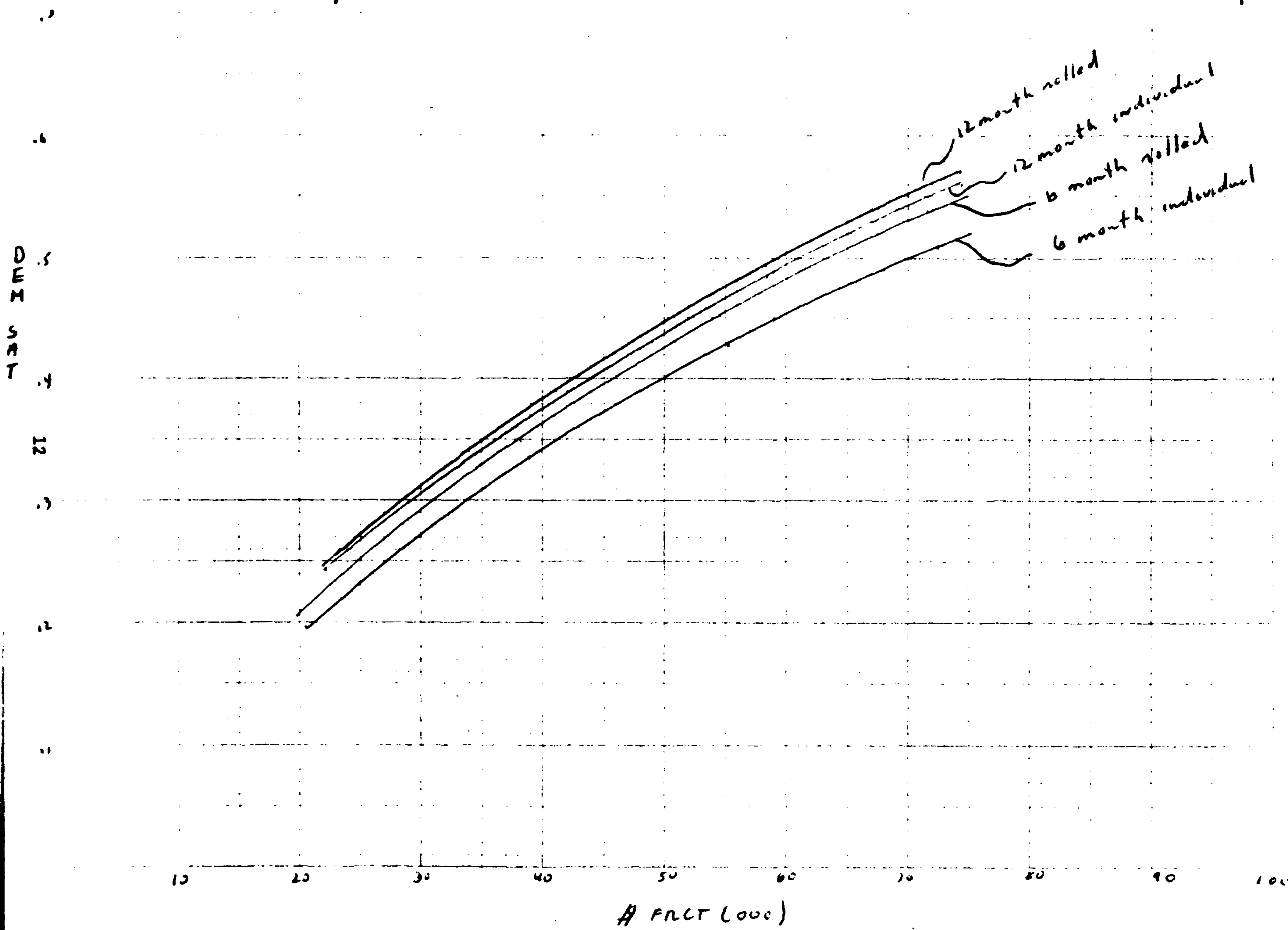
12 month base - individual vs rolled

Figure 3



ALL models/base combinations

FIGURE 4



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